BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

B69 07066

SUBJECT: The Artificial Production of a Respirable Atmosphere on the Moon and Mars - Case 105-1

DATE: July 22, 1969

FROM: W. R. Sill

ABSTRACT

Because the energy (10^{32} ergs) and raw material (3×10^5 km^3 rock) requirements are so large, it does not appear feasible to generate an oxygen rich atmosphere on either the moon or Mars.

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MEMORANDUM FOR FILE

In defining a respirable atmosphere for man we shall simply require it to be similar to the earth's at the surface, i.e., an O_2 partial pressure of .2 Atm (5×10^{18} molecules of O_2/cm^3) at a temperature of approximately 300°K.

Assuming an isothermal atmosphere the total amount of O_2 is

$$\# \text{ molecules of } O_2 = No\ H\ 4\ R^2$$

$$No = \text{surface number density} = 5 \times 10^{18}/cm^3$$

$$H = \text{scale height} = KT/mg$$

$$R = \text{radius of planet}$$

For the moon and Mars the total number of molecules of O_2 is of the order of 10^{43} (10^{20} grams) which is of the same order as the total amount of O_2 in the earth's atmosphere.

The atmospheric gases could be derived from the heating and decomposition of rocks. Heating to the point of outgassing would supply approximately 10^{19} molecules per gram of rock. The gases evolved are mostly CO_2 and H_2O which must be decomposed at a further expenditure of energy to obtain O_2. Because of its higher yield a more desirable approach would be the decomposition of silicate minerals which produces about 10^{22} molecules of O_2 per gram of rock. Taking the heat of formation of SiO_2(10ev/molecule) as typical of silicate minerals the production of 10^{43} molecules would require an energy expenditure of 10^{44} ev or 10^{32} ergs. The present U. S. electrical power output is 10^{26} erg/yr (3×10^{11} watts) and at this level of power input it would take 10^{6} years to produce the atmosphere. The required energy is equivalent to that of 10^9 megaton bombs and if a ten year time limit is set on the production this would require the energy from the release of 3 megatons/sec.

The amount of rock required as raw material comes to 10^{21} grams or about $3x10^5$ km^3. On the moon this corresponds to the top 10m of rock and Mars to the top 3m.

The above calculations assume that none of the gas produced escapes. For the moon with a thin, cold atmosphere, as would be the case during the initial stage, the thermal escape losses would not be significant. However, the fact that the moon retains little of the heavy gases (K_r, X_e) has been taken to indicate that other processes, such as an interaction with the solar wind, are much more efficient loss mechanisms for thin atmospheres. As the lunar atmosphere becomes thick - the mean free path less than a scale height - the exosphere can be expected to heat up (10^{3}°K) and the decay time ($\tau = \sqrt{2\pi H/g}\ (H/R)e^{(R/H)}$) for an O_2 atmosphere could easily be less than a year. Maintainance of an atmosphere under such conditions would be impossible.

In the case of Mars, its pre-existing atmosphere and ionosphere will protect the O_2 from solar wind losses. Because of the larger gravity and radius of Mars, thermal losses should not be a problem even for a hot (10^{3}°K) exosphere as the decay time is much greater than a billion years.

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